Chapter 1 - Introduction

The saiga (*Saiga tatarica*) is a migratory herding antelope found in Central Asia. During the course of its extensive migrations, it comes into contact with pastoral livestock, with which it shares many parasite species. Since the mid 1990s, there have been dramatic declines in the populations of both saigas and livestock in Kazakhstan, which could have affected the amount of contact between them, and the regulation and persistence of their parasites. With increasing concern over the conservation of saigas, meanwhile, knowledge of parasites that might either affect saiga populations or their perception as a risk to livestock is needed, in order to devise rational control strategies.

This thesis aims to further our understanding of the factors that affect parasite transmission within and between saiga and livestock populations in Kazakhstan. In particular, it sets out to:

- Quantify levels of parasitism in saigas, determine whether these have changed since previous surveys, and assess what effects parasites are likely to have on saiga populations;
- Determine how different factors can affect transmission and hence parasite burdens of saigas and livestock. Factors considered include climate and weather, changes in host numbers and distribution, differences in life history between parasite species, and the spatial scale at which variation is most important to parasite dynamics;
- Critically examine and, where appropriate, refine methods of parasitological investigation of wildlife populations in remote and difficult field conditions;
- Identify the key points of parasite transmission between saigas and between saigas and domestic livestock;
- Using these results, examine the likely effect of different control strategies on parasitism in saigas and livestock, and make recommendations for control strategies in the future.

A combination of approaches is used in pursuit of these aims. Chapter 2 summarises current theoretical and empirical evidence for the ways in which free-living wild animals and their parasites interact, and considers how this can inform us of the risks

and possible effects of parasite transmission across the wildlife-livestock boundary. The saiga-parasite system is characterised by long distance host movement, contact with other susceptible hosts, and a harsh external environment. These characteristics affect both the application of existing knowledge to the control of parasites in the system, and the implications of patterns observed in the saiga-parasite relationship for broader ecological understanding. The generality of conclusions drawn from parasitological studies of wildlife in relatively constrained ecosystems may be challenged in this more complex setting. Wildlife often exists in a situation where host movement, variable climate and contact with livestock are the norm rather than the exception. In this sense, saigas may provide a more 'natural' model for wildlife-parasite interactions than hosts that are isolated and protected from such complications, and the conclusions may be more directly applicable to other wildlife-parasite systems.

In Chapter 3, current knowledge of the saiga-parasite system is reviewed in the light of these general ideas. Abomasal nematodes are considered in most detail because of their potential importance as agents of disease. Previous work has succeeded in cataloguing the parasites of the Saiga, and those of livestock in its range, and has surveyed prevalence and abundance in some populations of both. Almost all is either published in Russian or remains unpublished, and has been conducted quite independently of evolving international thinking in parasite ecology. The chapter then asks to what extent parasite distribution in space, host movement, and underlying climatic patterns are likely to affect parasite transmission both within and between saiga and livestock populations in Kazakhstan. Understanding such interactions will be central to attempts to identify key times and places of transmission, and enable the design of rational control strategies.

Little previous work is amenable to quantitative analysis, while changes in host numbers and distribution in recent years might themselves have affected parasite abundance and transmission patterns. Sampling expeditions were designed to measure present parasite diversity and abundance in saigas and extensively grazed livestock in Kazakhstan. The methods used were adapted to the needs and limitations of the fieldwork, and may be useful in other studies of parasites in wildlife. They are described in Chapter 4.

Examination of nematode specimens collected in Kazakhstan revealed inconsistencies in the classification schemes used in the past, and therefore in both observed patterns of parasite diversity, and in conclusions drawn concerning host specificity. As assumptions concerning mutual susceptibility lie at the heart of any consideration of parasite transmission across the wildlife-livestock boundary, these inconsistencies were examined using morphometric analysis of specimens recovered from sheep and saigas. This is discussed in Chapter 5. Earlier assumptions concerning divisions within the genus *Marshallagia*, and their implications for perceived host specificity, are consequently re-evaluated.

Ultimately, nematode transmission within and between host populations depends on parasite abundance as well as just presence, and comparisons of parasite burdens between groups of hosts are central to understanding host-parasite interactions and transmission patterns. Chapter 6 reveals that this is not straightforward, and statistical comparisons of parasite abundance must consider both parasite distribution and observation uncertainty. A method is developed for the comparison of nematode burdens in saigas that takes both problems into account using maximum likelihood methods and bootstrap sampling.

This statistical model forms the basis of subsequent analysis of field data in Chapter 7, which aims to elucidate the main factors responsible for determining parasite burdens in the saigas and sheep sampled, and their likely impact on the host. Age-intensity patterns are used to assess whether density dependence is likely to be important to parasite populations, or whether other factors such as exposure patterns keep parasite burdens below levels at which immunity and parasite-induced host mortality would take widespread effect.

Regardless of interactions within the host, the effect of climatic variation on parasite development outside the host, coupled with host movement, is likely to determine the availability of infective stages to both saigas and livestock. A model of parasite transmission is developed in Chapter 8, which is designed to consider these factors. Experimental and field data on parasite development and survival in a variety of environmental conditions are used to develop and parameterise the model, whose predictions are then compared with patterns of parasite abundance observed

independently in Kazakhstan. The genera *Haemonchus*, *Marshallagia* and *Nematodirus* are considered separately, as their contrasting life histories might affect typical transmission patterns.

Chapter 9 considers the predictions of this model, and uses it to identify the most likely key times and places for the transmission of abomasal nematodes between hosts. The importance of assumptions concerning model structure and parameter values to the predictions is assessed, and used both to prioritise further work and to gain insights into the most important factors in parasite transmission. Manipulation of host and parasite populations in the model is used as a means of exploring the potential for control strategies based on host movement and strategic anthelmintic treatment.

Each chapter ends with a discussion of its findings in relation to the problem in hand. Finally, in Chapter 10, the questions posed at the start of the thesis are re-evaluated in the light of all the results presented. Recommendations are made for the control of parasite transmission between saigas, and between saigas and livestock, in Kazakhstan. The implications of the findings presented in the thesis for our general understanding of the dynamics of wildlife parasites are discussed, and further work is suggested that will improve our understanding of parasite transmission in this system, and at the wildlife-livestock boundary in general.